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The Welsh Engineers' and Founders' Association
The Foundry Trades' Equipment and Supplies Association

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Limitation of Home Trade

The repercussion on the foundry industry by the imposition of the Limitation of Supplies (Miscellaneous) Order, 1940, is likely to be profound. Not only is there a direct impact, but by the very nature of the Order the indirect influences will be onerous. Every firm carrying on the business of supplying any class of controlled goods in the manufacture of which it has carried out a process, or who buys for resale, is required to apply to the Board of Trade to be registered as "controlled suppliers." Thus retailers are excluded. From June 6 to November 30, 1940, the supply of goods is to be restricted to two-thirds of the goods made for the home trade during a similar period last year, the restriction being calculated by value and not quantity. Each controlled supplier is required to apply on forms issued by the Board of Trade to-day at the latest, as announced last week. Applicants' names appearing on the register will be informed as soon as possible. The returns have to be certified by an auditor and the necessary documents be made available for inspection. All registered persons may supply without restriction any class of controlled goods to any person whose name is included in the register for that class of controlled goods; goods required for the execution of contracts with Government Departments and direct to overseas markets.

The restriction to be made must be computed in respect of each class of controlled goods, and suppliers may be registered in respect of one class but not in others. Thus reference must be made to the Register to ascertain in what class or classes in which he deals each of his customers is or is not registered.

The Order defines the value at which supplies are to be taken into account. Normally, this value will represent the net sale price on which invoices to customers are based. The following represents the scheme for computing the value of the permitted home supplies. In respect of each class of controlled goods, there must be an ascertainment of total value in the period of June 1 to November 30, 1939, and subtracted therefrom the value of those supplies which are detailed above as being unrestricted. From this there is to be subtracted the amount of any commissions and delivery charges, and finally from the net total one-third has to be deducted.

Amongst goods which have been controlled and which incorporate castings there are the following:—Various sorts of metal furniture, including bedsteads and hearth furniture; various interior lighting fittings; all types of domestic hollow-ware, including baths; musical instruments (pianoforte frames); sports goods; toys; cash registers; plate washers; hairdressers' machines, lawnmowers, washing machines, including wringers; refrigerators (with a storage capacity not exceeding 12 cub. ft.); electric washers, irons, plate warmers and kettles. In many cases we have touched only on the main headings, for hidden amongst other classifications are dozens of other types of castings such as are incorporated in automatic coin delivery machines. A rather striking omission is garden rollers. Taking the Order as a whole, a wise choice has been made, for it is clear that the goods listed can, generally speaking, be the subject of economy without much personal inconvenience.

It should not be presumed that, because a limit has been set, there is a prescriptive right to make the quantity indicated, as the whole situation is still governed by the raw material allocations sanctioned by the Ministry of Supply.

Small Economies

Much fuel is lost daily in the foundry industry by insufficient appreciation of the fact that it costs money to remelt good iron, and an additional expenditure is required if this iron be dirty. Even now not every foundry has provided chills for taking care of the overmelt, or iron too cold to be cast into moulds, and the old-fashioned system of pouring it into a small pig bed still persists. Such methods involve the need for more fuel and perhaps flux for its remelting. Another direction where money can be saved is in the larger foundries where very frequently samples of liquid metal are taken for control purposes, usually based on the depth of chill thrown. One very large foundry, realising that a reasonable quantity of metal is essential for obtaining comparative results, uses the excess for casting core grids. As in this particular case several types of grids and grates are required in quantity, permanent metal moulds are provided. A third potential saving can be made by attention being given to slags. Where a cupola is yielding a heavy black slag, it means that much metal is being wasted. Careless teeming, usually associated with the use of unskilled labour, is a potential source, not only of metal being wasted by spilling, but also of waster castings. As much help as possible should be given to beginners to give them the necessary confidence to avoid wastage. In any one concern, these little economies may seem of small importance, but spread over the many hundreds of British foundries they will assume serious proportions

Correspondence

[We accept no responsibility for the statements made or the opinions expressed by our correspondents.]

Electric Furnace Melting Costs

To the Editor of THE FOUNDRY TRADE JOURNAL.

SIR,—I have read with interest Mr. F. W. Rowe's letter on the above subject in your issue of June 6. I agree almost entirely with Mr. Rowe's remarks as far as they go, but I suggest that even further amplification is desirable before a true comparison is obtained.

I have found that the majority of users accept a figure of 14 or 15 per cent. for capital charges covering amortisation and interest, and I agree that this has an important effect upon a comparison between the high-frequency and the arc furnace. Moreover, the working hours or output per week have a direct bearing upon the comparison. In normal times the working of one day shift is very often usual in steel foundries, with the result that the capital charges per ton melted become three times as high as with 24 hours' operation. The capital charges on an arc furnace are very much lower than for a high-frequency plant, and this factor of output alone may determine which is the cheaper to operate.

What I consider is more important, however, is that more often than not the high-frequency and arc furnaces are doing entirely different jobs. The high-frequency furnace is mainly a remelting unit utilising high-grade scrap of known composition as its raw material. The arc furnace, especially in this country, is more often operating on relatively low-grade raw material and producing a high-grade steel by a *refining* process. Obviously these two processes cannot be compared unless the cost of raw material is brought in, when in most cases, I maintain, the arc furnace will be found to be the cheaper.

A truer comparison would be between the high-frequency furnace and the modern arc furnace, using the acid process on the same raw material and between furnaces not necessarily of the same size but giving the same output. The facts at my disposal show that under such truly comparable conditions the arc furnace is the cheaper melting unit.—Yours, etc.,

A. G. ROBIETTE.

Birmingham Electric Furnaces, Limited,
Tyburn Road, Erdington, Birmingham.
June 12, 1940.

More Export Groups

Export Groups have been formed in the following trades and industries. The addresses are those of the secretaries of the groups:—

Aluminium Hollow-ware, British Aluminium Hollow-ware Manufacturers' Association, 95, New Street, Birmingham.

Electro-Plating, Polishing and Finishing Equipment, 5, Bennetts Hill, Birmingham, 2.

Ferrous and Non-Ferrous Valves, 32, Victoria Street, London, S.W.1.

Roll Makers, 21, Bennetts Hill, Birmingham, 2.

Scientific Instruments and Appliances, 60, Queen Victoria Street, London, E.C.4.

Steam Engine, 36, Kingsway, London, W.C.2.

Water Purification Plant, 94-98, Petty France, London, S.W.1.

Winding Engine, 36, Kingsway, London, W.C.2.

Spectrographic Analysis of Steel

MR. J. L. GREGG and MR. P. R. IRISH, of the research department of the Bethlehem Steel Corporation, writing in a recent issue of "The Iron Age," describe methods for the spectrographic analysis of steel and state that quantitative determination can be carried out quickly and cheaply by this means with an accuracy comparable with routine wet analysis.

Institute of Vitreous Enamellers

NO QUORUM AT BIRMINGHAM MEETING

An extraordinary meeting of the Institute of Vitreous Enamellers was convened for the afternoon of Tuesday, June 11, at the Chamber of Commerce, Birmingham, to consider an alteration in the Articles of Association. Mr. W. H. Whittle (chairman of the Council) took the chair at 2 p.m. and had the support of seven other members. The number fixed by the Articles as constituting a quorum is 25, and as, at the expiration of half an hour, no further members were present and no proxies had been received, the chairman declared that the meeting stood adjourned until Tuesday, July 9. *The meeting place will again be the Birmingham Chamber of Commerce, and the time* 2 *p.m.* Members have been circularised to this effect, and those who cannot attend are asked to send proxies.

The Article of Association for consideration is number 28, the proposal being that this should be deleted and the following substituted: "The Council shall consist of 11 ordinary members of the Institute, comprising a President, hon. treasurer, and not more than nine ordinary members. In addition, the chairman and secretary of each Branch or Section of the Institute shall be *ex-officio* members of the Council."

PAPER CONSERVATION AND THE EDITORIAL INDEX

In order to conserve paper, the editorial index for the current half year will not be included, as hitherto, with each copy of the Journal as a loose insert, but will be sent to readers who write to the Publisher, "The Foundry Trade Journal," 3, Amersham Road, High Wycombe, Bucks, expressing their wish to receive a copy. Please make early application in order that the correct supply may be printed.

Collection of Scrap

The British Iron and Steel Corporation has formed two small private companies, one to deal with salvaged shipping wrecks and the other with scrap collected through the various voluntary schemes now in operation. The first company is called British Iron & Steel Corporation (Salvage), Limited, and the second British Iron & Steel Corporation (Scrap), Limited, and each has a nominal capital of £1,000.

The Corporation, which was formed in 1935 as part of the machinery for the reorganisation of the iron and steel industry, already carries on as part of its business the buying and handing over to merchants of scrap obtained from foreign sources, but that salvaged or collected under voluntary schemes comes outside this activity. Separate agencies are therefore necessary for internal reasons. The new companies will arrange and pay for the transport of the scrap which is coming forward from salvaged wrecks and as a result of special appeals throughout the country. This will be collected in dumps and merchants will be asked to tender for the supplies.

Stainless and Heat-Resisting Castings

The "Iron Age" reports that, consequent upon a survey it instituted of what is estimated to be 94 per cent. of all consumers of stainless and heat-resisting castings in the U.S.A., it can now be stated that the total consumption in 1939 was of the order of 9,646 net tons. The total was made up of 1,204 tons of 18 per cent. Cr, 8 per cent. Ni; 1,293 tons of 25 per cent. Cr, 12 per cent. Ni; 551 of 12 to 14 per cent. Cr; 357 of 16 to 18 per cent. Cr; 298 of 18 to 30 per cent. Cr, and 5,925 tons of all other varieties of Cr and Ni-Cr steels.

Physical Properties of Alloy Steels at Low Temperatures

In a study of some of the physical properties of alloy steels at low temperatures, A. KRISCH and G. HAUPT, according to their report in the "Archiv für das Eisenhüttenwesen," have measured the notched-bar and hardness values and tensile strengths of 62 specimens, first at room temperature and then at the temperature of liquid air. Notched-bar measurements of a number of nickel, chrome and chrome-manganese steels, particularly those with an austenitic structure, as well as of nickel-copper and lead, showed that a high plastic deformability was retained at − 183 deg., and low-alloy martensitic steels without exception showed a reduction in notched-bar values, the highest values being obtained with those alloys containing nickel. Certain chrome-molybdenum steels gave values as high as 5 mkg. per sq. cm., while heat-treated steel usually gave a lower notched-bar value at low temperatures. Soft iron became completely brittle at low temperatures, and the notched-bar values of copper and lead increased with reducing temperature.

The hardness of the specimens examined was found to increase in all cases as the temperature was lowered. Materials with a high hardness value at ordinary temperatures suffered a comparatively smaller increase in hardness on temperature reduction than those with a low hardness value at room temperatures; the increase in hardness appears to be associated with the chemical composition of the material. The greatest change in hardness was revealed by soft iron and lead. The yield point and the tensile strength also increased at lower temperatures, such increases being related to the tensile value at ordinary temperatures. The total elongation is not as dependent on the temperature as the other properties studied, while in some cases necking is reduced to half. In chrome-molybdenum, chrome-nickel-vanadium and chrome-nickel-molybdenum steels, the ratio of tensile strength to hardness increases down to − 183 deg. C. only within the limits of experimental error.

Notes from the Branches

East Anglia—A meeting of the East Anglian Section of the Institute of British Foundrymen was held in the Central Library, Ipswich, last Thursday. The Junior Vice-President (Mr. C. J. Lake) occupied the chair, and announced with regret that Mr. H. A. Fox was unable to be present to deliver his lecture on "The Ford Foundry and Production of Castings for the Ford Car." This disappointment had occurred at very short notice, and Mr. J. L. Francis had, therefore, very kindly offered to read the Paper on "Production of Pressure-Resisting and High-Duty Iron Castings," which he had prepared for presentation to the Annual Conference. (See page 469.)

MR. C. H. KAIN, in proposing a vote of thanks to the lecturer following delivery of the Paper, said how grateful the members were to Mr. Francis for stepping into the breach. The Paper was a very useful contribution which members would wish to study at their leisure when it was published in the FOUNDRY TRADE JOURNAL.

MR. C. J. LAKE also voiced appreciation of the efforts made by the lecturer.

MR. J. L. FRANCIS thanked the meeting for the way in which it had received the somewhat hurried and *impromptu* presentation of the Paper.

The next meeting will be held on July 11, in the Central Library, Ipswich. Mr. N. L. Evans will then speak on "Sodium Carbonate in Iron Manufacture and Founding."

Chromium Heat-Resisting Cast Irons

By R. C. TUCKER, M.A.

This Paper was prepared for the annual meeting of the Institute of British Foundrymen, and written discussion is invited. Contributions should be sent to Mr. J. Bolton, Institute of British Foundrymen, St. John Street Chambers, Deansgate, Manchester, 3

It is the author's intention to portray the present knowledge of heat-resisting cast irons, with special reference to chromium cast irons. He will only touch upon some of the highly-alloyed cast irons, Ni-Resist, Nicrosilal, Silal and Cralfer, because these are the results of investigations carried out by large research organisations, and there is a constant flow of reports concerning these alloys emanating from the interested organisations. There is no central industrial or research organisation devoted to the study and commercial application of chromium alloys as in the case of nickel and molybdenum alloys. The result is that published data tend to have an "interested" bias, and it will do these alloys no harm for someone to point out in as unbiassed a manner as possible the results which can be obtained by the use of chromium alone.

The simplest type of heat-resisting cast iron available to-day is "hematite," which loose but traditional phrase covers a wide range of structures and types. By weight, it is the most important heat-resisting cast iron and in spite of the long period over which it has been used in heat-resisting conditions there are still many problems associated with its use.

The Ingots Committee of the Iron and Steel Institute has, as all cast-iron metallurgists know, published some very interesting reports on the life of "hematite" cast-iron ingot moulds, and their conclusions are roughly as follows:—

(*a*) It is only possible to determine the factors affecting the life of ingot moulds by the careful statistical analysis of a large number of carefully controlled service tests.

(*b*) The presence of 10 per cent. of steel in the cupola charge can have a beneficial effect in some cases.

(*c*) The presence of up to 0.3 per cent. of phosphorus has a beneficial effect and is not more common because of the widespread practice of introducing scrap moulds into the acid open-hearth process.

It is very likely that no such complete analysis of service results has been attempted in any other type of service. Most of the service conditions of heat-resisting cast iron are not under strict control and service records unless of a statistical nature are distinctly misleading in many cases.

"Hematite" cast iron does not resist oxidation, is very prone to "growth" and is mechanically weak on "static" tests. Its only good quality is its ability to resist major cracking caused by heat shock, and there seems to be distinct evidence that the worse it behaves when tested in the ordinary ways, the better will be its resistance to heat shock. The present method of testing for heat-shock resistance is to water-quench 1-in. dia. test-pieces from 650 deg. C. a number of times. This test, like many other laboratory tests, has many limitations because it is difficult to introduce the factors of thickness and shape, and, in any case, almost any hematite cast iron will resist this test for a large number of quenches.

It has been found, however, in studying ingot moulds (*loc. cit.*) that certain microstructures are desirable for the avoidance of major cracking (Fig. 1). The coarse graphite is surrounded by ferrite with only small amounts of pearlite and other impurities, and this is perhaps the best test that can be applied in the absence of service records.

Pig-Casting-Machine Moulds

Some years ago the author encountered some surprising results in the manufacture of pig-casting-machine moulds, and a description of the case will, no doubt, raise a sympathetic feeling in the minds of many foundrymen. Tradition said that such moulds should be made in pure West Coast hematite. The Ingot-moulds Sub-committee and private investigation were beginning to point to the use of some steel and phosphoric iron as indicated above.

Boldly, these were introduced and two sets of moulds to the same design went through the shops at the same time and were installed indiscriminately on two new machines. In a few months, from one machine, came a serious complaint of major cracking, from the other a satisfactory report. Visits to the machines and careful investigation showed that the service conditions were widely different. The replace moulds for the cracked moulds were made in pure West Coast hematite, and the complaints ceased for a time. Later, however,

FIG. 1.—MICROSTRUCTURE OF GOOD HEMATITE. × 500.

several more orders were received, indicating a continuance of rapid failure and similar lack of satisfactory service from other suppliers! Obviously, if the moulds are of uniform quality, and the machine starts with all new moulds, there will come a period of very heavy replacements followed by an apparent improvement, followed again by a period of fairly heavy replacements, the intensity of these periods gradually dying down to a fairly uniform wastage.

A heavy mild-steel frame mounted on trunnions was made and a set of six moulds mounted on it:—

(*a*) Two in West Coast hematite of an approved analysis.

(*b*) Two of a 10 per cent. mild-steel mix with East Coast hematite and of almost identical chemical analysis.

(*c*) One mould of (*a*) plus 1 per cent. nickel.

(*d*) One mould of (*a*) plus 1 per cent. copper.

These were limed and repeatedly filled with molten foundry iron, and cooled with a hose as nearly as possible as in practice. They were rotated and tipped, "stickers" were removed with a crowbar and the underside was hosed for a similar period. They were then re-limed and refilled with molten metal as soon as possible. The two alloyed moulds showed early cracks at the lip which gradually increased in size. The other moulds showed no sign of major cracking for 200 casts, except for some very small cracks on the lips, after 100 casts, which appeared unchanged after 200 tests.

The moulds were then placed in general use for casting spare metal in the foundry, and after several months without liming or quenching gradually failed by growth and the tearing out of lumps from the bottom by "stickers." This test reproduced as nearly as possible service conditions in a normal pig-casting machine and agreed with the results obtained in the complaint-free machine.

The other machine was operating in conditions which are comparatively new to the pig-iron industry, and these conditions lead to rapid failure of almost any type of cast-iron mould. This has been confirmed by two other cases. This example shows how departure from precedent can bring a host of recriminations about the ears of the foundry technical staff from customer, sales and drawing office if it coincides with a change in service conditions.

The improvements to be expected by departing from precedent are probably small, and of the order of a 10 to 15 per cent. increase in life at the most, and the author is now firmly convinced that the introduction of steel and phosphorus into an established good hematite mixture is a step in the wrong direction where heat shock is probable.

Recently, the B.C.I.R.A. tried their titanium-carbon dioxide method of refining the graphite in these irons, and a set of ingot moulds was cast. Some improvement in life was noticed, but the test should be done in moulds that are

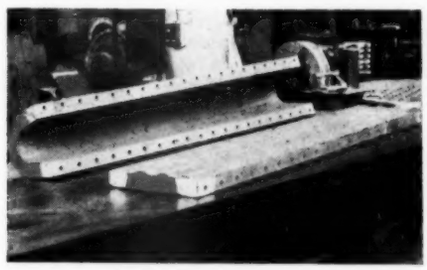

FIG. 2.—LOW-TEMPERATURE CARBONISATION RETORT CASTINGS IN LOW-CHROMIUM IRON.

prone to periods of major cracking, *i.e.*, mould designs that are on the limit of safety, and the results of such tests are awaited with interest. The refining of the graphite should improve the resistance to growth.

High-Duty Cast Iron

The next group of cast irons used for heat resistance is synonymous with the group known as high-duty cast irons and made usually for their mechanical properties. Of these the earliest was "Lanz Perlit." They have a rather more stable pearlite and finer graphite than ordinary foundry iron. These two factors enabled experimenters (*e.g.*, Dawson) to demonstrate their superior growth resistance at 450 to 550 deg. C. At higher temperatures, however, and for intermittent service the difference is very small. They generally do not resist to scaling or heat shock, and on short-time tensile tests their strength is only maintained up to 500 deg. C. These irons contain no carbide stabilisers or special strengthening elements and are not very important from this point of view.

Low-Alloy Cast Irons

The third group consists of low-alloy cast irons designed for specific purposes, and the influence of special elements begins to be felt.

These low-alloy irons are not resistant to heat shock and are only very slightly more scale resistant than ordinary engineering cast irons (*q.v.*). The properties which must be sought are, therefore, machinability, good foundry properties, growth resistance, toughness and strength at operating temperatures.

The author has found, from practical experience, that these low-alloy irons depend for their properties on very close control of the structure and analysis, and a combined carbon of 0.8 to 1.3 per cent. is aimed at in most cases. It is only possible to control the structure by the use of modern methods, as the old methods of chromium addition were uncertain. Much has been written about the difficulty of dissolving high-carbon ferro-chrome in cast iron, and it is true that, with dull iron, hard spots are often encountered. The problem is not one of melting the ferro-chrome, but is one of dissolving it, and the proper operation of the cupola gives metal hot enough to *dissolve* completely the high *melting* carbides of 4 to 6 per cent. carbon ferro-chrome.

The addition of chromium can be accomplished in various ways. Lump ferro-chromium in the cupola often spreads to other charges and is usually unsuitable except for melts of some tons collected in one ladle and well mixed. Ferro-chrome briquettes are much more satisfactory, and a trial carried out on a 10-ton

FIG. 3.—MICROSTRUCTURE OF LOW-CHROMIUM CAST IRON. × 250.

casting when these briquettes first became available gave the following results:—

Metal in ladle.	Chromium. Per cent.
3 tons	0.60
5 tons	0.62
7 tons	0.63
10 tons	0.62
Sought	0.60 to 0.70

The cheaper variety at 4 to 6 per cent. carbon is quite satisfactory, and there is no need to purchase the low-carbon material. Crushed 4 to 6 per cent. carbon ferro-chrome can be added to the cupola stream in amounts up to 0.6 per cent. Cr when treating small quantities of standard metal. The ladles should be weighed, but it is nearly always sufficient to exercise proper control on ladle lining and to estimate the quantity of metal by eye. If closer control of ladle additions is necessary, then powdered ferro-chrome is an unsatisfactory material (as is powdered ferro-silicon or ferro-molybdenum), because some of the powder is invariably blown away from the falling stream by air currents.

The most accurate and reproducible method of chromium addition is by the use of modern exothermic mixtures. The most satisfactory so far tried by the author is of Canadian origin, and is marketed under the name of Chrom X. This material is in the form of 10-lb. bricks, each containing 5 lbs. of chromium and giving practically 100 per cent. recovery. They consist of chrome ore mixed with carbonaceous and exothermic material and are usually added to the ladle. They are deliquescent and must be dried before use, unless a hot ladle is available; in the latter case the material is placed in the hot ladle and the action starts immediately. The material glows white hot and dissolves completely in the metal when it is tapped on to it. The slag is alkaline and gummy and should be dried up by lime unless teapot ladles or a mixer be used. The slight inconveniences of drying the bricks and dealing with the slag are hardly noticed in a well-run foundry and are well balanced by the certainty of the results obtained.

It is far easier to control chromium by this method than by any other simple and inexpensive method. When added to the cupola charge, the bricks remain in their correct charge and tests carried out by the author indicate that the chromium lost in this way is less than 5 per

FIG. 4.—CHEMICAL RETORTS CAST IN LOW-CHROMIUM CAST IRON.

cent., as compared with 15 to 20 per cent. with briquettes.

In order to see how much chromium can be added by the use of Chrom X, a severe test was carried out in the following way. A 10-ton ladleful of low-chromium cast iron (0.62 per cent.) was well mixed by "rodding" and sampled by means of a hand ladle for a chill test. About 20 lbs. of metal was left in the hand ladle and Chrom X broken up was added to give a maximum of 10 per cent. of chromium. The slag and compound were skimmed off before the action ceased and a test-bar could still be poured from the metal. In fact, fluidity seemed to be unimpaired. The chromium in the test-bar was 6 per cent. In a repeat test under more favourable conditions, about 20 lbs. of hot metal (free from chromium) were poured on to 4 lbs. Chrom X (= 10 per cent. Cr), reacting in a hot hand ladle and the reaction allowed to go to completion. The slag was held back and a test-bar cast. The analysis showed 10 per cent. chromium.

Types of Low-Chromium Irons

The various types of low-chromium cast irons used for heat-resisting purposes are as follows:

(*a*) Low-temperature carbonisation retort castings operating at 700 deg. C. These castings, shown in Fig. 2, are 1 in. thick and 10 ft. long and must be machined on each flange. There were occasional complaints of hard corners, but when the machine shops became used to them and a suitable technique was adopted, no further troubles were experienced. Carbide-tipped tools could not be used because of holes cored in each flange to take bolts. The castings have proved very successful in service and only "grew" ¼ in. in length in two years, except on one plate where poor conditions had led to direct flame impingement. After re-machining to size the castings went back into service for a further campaign.

The metal used was of the following average composition: T.C, 3.25; Si, 1.35; Mn, 0.6; S, 0.1; P, 0.3; and Cr, 0.6 per cent.

These castings would be a much easier proposition to-day because of the greater control over the chromium additions, although the control was made sufficiently good for the job by the use of rapid chill tests and adjustment of the metal in the ladle by soft iron. The structure of one of the castings, which is shown in Fig. 3, is a carbide network with pearlite and medium graphite, and hard spots were encountered on machining (combined carbon is 0.86 per cent.).

The next problem was the manufacture of chemical retorts for use at 850 deg. C. Two of these 9-ton retorts (3 in. thick) are shown in Fig. 4, and a similar composition (T.C, 3.25; Si, 1.2; Mn, 0.6; S, 0.1; P, 0.1; and Cr, 0.65 per cent.) was adopted with due regard for the extra thickness and increased danger of cracking.

These castings have stood up very well in service and the temperature has been raised to 950 deg. C. without decreasing the life. They are too large to test easily and, as no wasters have been made as yet, it is only possible to judge the initial structure by the

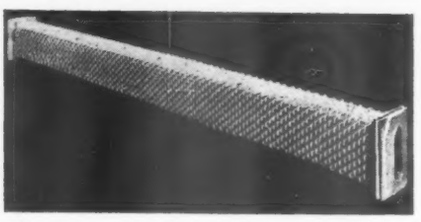

FIG. 5.—NEEDLE EXCHANGE ELEMENTS CAST IN 30 PER CENT. CHROMIUM ALLOY.

appearance of the head or ingate. There is a minor carbide network and fairly coarse graphite. After service the structure is very similar to that shown in Fig. 12, showing that after the carbide has been spheroidised, there is little further change.

Heat-Exchange Elements

A more difficult problem is encountered in the manufacture of the well-known Newton needle heat-exchange elements, because the thin sections and needles (Fig. 5) demand very fluid metal. Apart from any metallurgical requirements, it is only possible to cast these elements with few rejects if the body of the casting be grey. It is necessary therefore to determine the best composition and structure which will not only meet the service requirements, but give little trouble in the foundry. Again, chromium cast irons have proved the most satisfactory all-round material, but over 1 per cent. chromium is necessary, with silicon raised to give the desired structure. At one time it was thought that a slight modification of the previous compositions would be ideal, but if the cross-section is too small to allow the full development of the carbide network found so useful in the thicker castings and if the castings are made soft enough to be grey with the low-chrome: low-silicon alloy irons, there

(*Continued on page* 471.)

Coatings for Wood Patterns*

By FRANK C. CECH and VINCENT J. SEDLON

In considering certain activities of the Patternmaking Committee of the American Foundrymen's Association, a suggestion was made to the authors that a survey of materials and methods for coating wood patterns would be of interest to many. The writers were invited to make such a survey and report at the 1940 annual meeting.

During the 1914-18 war, shellac was hard to get, and rose to a price that almost prohibited its use for pattern work. Consequently, a varnish was developed that dried fairly well in about 2 hrs. It was difficult to sandpaper, as it was tacky and accumulated in resinous streaks, much as shellac does when sandpapered before it has had sufficient time to dry thoroughly. Its use was short-lived. Then came lacquer, which has been used with more or less success, but its use on patterns has not been as extensive as will be necessary before passing final judgment on it. Patternmakers are sceptical of using any material but shellac and those concerned are loath to try substitutes.

Objectives and Procedure

The objects of this Paper are as follow:—

(1) To secure such information as can best be given by a manufacturer or distributor of shellac or varnishes that might be used as a pattern coating material.

(2) To present results of applying wood-pattern coating materials submitted for a trial or test.

(3) To secure information pertaining to materials actually used by the pattern industry in coating wood patterns under average pattern-shop conditions.

(4) To summarise all information gathered from the *questionnaires,* make it available to all, including the interested layman having no patternmaking experience.

(5) To draw a conclusion that might be used in recommending standards to be used in specifying as well as manufacturing wood patterns.

Questionnaires were prepared for (*a*) the manufacturer and distributor of shellac and varnishes, and (*b*) the patternmaker or person actually engaged in applying the pattern coatings. The questions were of a type easily answered but permitting elaboration where necessary.

Experiments with a number of patterns made from various types of timber and bearing different coatings were inconclusive, if the various means of experimenting are considered. For instance, the colour combinations applied were on mahogany only and not on pine. Would the results have been the same as on mahogany? Only further experimentation would prove this. Also a further experimentation with thinned-out varnish on mahogany might react differently from the way it did on pine, etc.

Mention has been made of a varnish used during the world war, and the varnish tried here shows much better results than those available at that time. The spreading qualities were above average and the fluidity made an even coating showing no overlap or run. The cost of the varnish is about 15 per cent. higher. Whether industry would be willing to pay this additional charge, sacrificing as it must some time in waiting for the varnish to dry, is difficult to answer. It would be well to experiment further with the pattern used in the experiments, or other designed patterns, under more varying circumstances to discover a better coating, if possible.

Results of Questionnaire Directed to the Pattern Industry

A second *questionnaire* was distributed to 273 pattern manufacturers, of whom 90, or roughly 34 per cent. answered. In drawing up the *questionnaire,* it was thought advisable to differentiate between the large, medium-sized and small work to allow for a variation in coatings, their treatment or application.

After tabulating the returns, the differences found were so slight that all three classes have been combined under the same heading. It may be of interest to note that two-thirds of the *questionnaire* was devoted to shellac, lacquer taking the remaining third.

Summary of the Answers to Questionnaire

Summarising the returns of the manufacturers and distributors, and especially the reports of the research and similar departments representing the manufacturers, reveals little experimentation on coatings for wood patterns. There may be several reasons for this. Lack of market appreciation may be one. It might be pointed out that the value of the pattern industry in the vicinity of Cleveland alone represents a total annual expenditure of approximately £400,000. What percentage of this total valuation represents the cost of coatings for pattern equipment is difficult to say. However, it must be high enough to warrant experimentation for a new coating. Ignorance of the market for such a coating, lack of specifications or listed requisites of the coating, and a laxity on the part of the user to acquaint the laboratories of the paint and varnish companies with these facts, along with an expression of a desire for a new coating, may also be responsible for the absence of said experimentation.

The results of the test performed in connection with this survey have been along practical lines, elementary and incomplete, and it is hoped will be the basis of a future Paper.

Coatings and Their Preparation

The returns of the survey indicated that shellac is preferred as a pattern coating, ranking as first choice. The second choice is lacquer, with shellac as a priming coat, followed by the use of lacquer entirely as a third choice.

Most pattern manufacturers prefer to handle shellac in flake form and dissolve it in quantities as needed. Only about one out of every four purchase their shellac in liquid form. A popular method of cutting shellac is to place flakes in a container and add enough solvent to cover the flakes, stand for 24 hrs., stir, thin down by adding solvent to desired consistency, and strain through cloth before using.

Solvents

Denatured wood alcohol is used as a solvent by one-half of the industry. It seems to meet all the requirements. Other preparations have entered this field and are gaining in popularity. Users of these preparations average around 36 per cent., all receiving satisfactory results. The prohibitive price of grain alcohol has apparently discouraged its use as a solvent for shellac. However, it should not be overlooked, as its value for this purpose is ideal. About 17 per cent. of those answering the *questionnaire* still use grain alcohol.

Black Pigments

Familiarity with patterns reveals the necessity of identifying parts by colouring. Pigments of various colours are introduced into the shellac for this purpose. A black extract, known by various trade names, and lampblack share about equal popularity. Advocates of the extract claim a deeper penetration of the colour into the wood and a better finish. Lampblack users claim that patterns draw better and have a harder finish.

Red Pigments

Red shellac is also used in pattern identification. There are two outstanding pigments in use for this purpose, English vermilion and domestic vermilion. English vermilion is richer in colour and stronger in colouring properties but higher in cost. Many manufacturers are using the domestic vermilion with good results. In both cases, the specific gravity is lower than shellac. A lighter pigment stays suspended in solution, a heavier one is deposited and necessitates stirring before application. The choice of the manufacturers is about equally divided.

Yellow Pigments

Another colour used on patterns is yellow. For this purpose, chrome yellow, coloida-lac and andel yellow pigments are used in the shellac. Clear shellac is often used on the bare wood for this purpose. Both methods are considered practical and develop contrast in colours with red and black. In certain instances, where changes in patterns alter the contours of previously painted patterns, the yellow pigment may be necessary to cover parts which were previously black or red. Clear shellac, being transparent, is not practical in such cases.

Aluminium Coatings

On the subject of aluminium coatings, about 22 per cent. use aluminium powder in shellac. The survey reveals that, although it has merit, there is also considerable criticism. A statement from two foundrymen deserves mention. They claim better drawing results and a longer wearing surface; others are not entirely satisfied. The latter claim that aluminium wears too fast and that they can see no advantages. Experimentation with aluminium coatings is warranted because of its recent appearance.

Preparation of Powder Pigments

It is necessary to prepare powder pigments before their introduction into shellac as they do not dissolve readily. The most popular method is to add enough solvent to the pigment to form a paste, mix well, thin to the consistency desired, and strain through cloth before introducing into the shellac. Black extract powder is soaked for 24 hrs. in a solvent, then stirred and strained through a cloth.

Priming Coats

The observer of the finished product may not attach much importance to the question of whether the first, or priming coat, was clear shellac or a coloured shellac. When the colour penetrates the wood, it is naturally easier to cover with the second coat. However, it does take more time to apply the various colours on the first coat. Advocates of each method stress such points as wear, harder finish, better appearance, better adhesion, etc.

Number of Coats for Various Patterns

A pattern falls into various classifications, according to the expectancy of its use. A product for one casting does not warrant the cost of a finish that will outlive its use. Conversely, a high productive expectancy from a poorly-coated product is absurd. For this information, patterns were divided into three classes as follows:—(1) Temporary (or 1 to 3 castings), (2) mediocre (or 10 castings and occasional repeat order), and (3) standard (or production run).

One coat of shellac to fill the pores of the wood and to raise the grain, sanded down to a smooth finish, is the popular procedure on a temporary pattern, two coats being applied for the mediocre pattern and three coats for the

* Extracted from a Paper presented to the Chicago Convention of the American Foundrymen's Association. The authors are Instructor in Patternmaking, Cleveland Trade School, and a member of the Master Pattern Company respectively.

standard pattern. It is generally accepted that the consistency of the shellac should not be thick. Three thin coats are much better than two heavy applications.

Use of Oxalic Acid

Subjected to exposure in containers, shellac becomes cloudy and has a dirty appearance. This is often corrected or cleared up by the use of oxalic acid. It is not a good practice, because the acid tends to break down the body of shellac, causing considerable trouble, such as retarded drying and sticking to the sand. It is being used sparingly in reclaiming shellac

Brushes and Containers

A noticeable discoloration is caused by brushes with a tin binding, and for this reason brushes with a hard rubber binding are preferred for shellac, though many using brushes with tin binding claim no objections and prefer them because they are easy to clean.

Suitable containers are important in preservation of shellac. Glass and crockery are most commonly used. They are easy to clean and immune to attack of solvents and chemical reactions. Metal containers, properly coated to prevent chemical reaction, also are used because they are durable and not subject to breakage, as well as being light in weight. Wooden containers are also practical and economical.

Lacquers

Lacquer has gained the favour of many manufacturers as a suitable pattern coating. Eleven per cent. of the industry is using this material as a final coat over the shellac primer and 7 per cent. use lacquer exclusively. Shellac is used as a primer because of its value as a wood filler and its quick drying properties. It is also easier to sand smooth and more economical than lacquer. At points where wax is used, as in fillets, etc., these surfaces must be coated first with shellac because lacquer does not adhere to wax and reacts chemically with it.

As a finishing coat, lacquer is claimed to make a harder, and consequently a better wearing surface than shellac. Lacquer is also moisture proof and patterns so coated draw well. It is available in colours, thereby eliminating pigment preparation, and has a fine appearance. The spraying of patterns is not practical because of the colour combinations used on patterns, and because spraying fumes are objectionable. The best results are obtained by brushing.

The following is cited from a letter received from a manufacturer. It is a definite challenge to further research:—

"We have investigated, as completely as possible, our experiences on the finishing of wooden patterns. We have not found anything better than shellac for this purpose, considering cost, convenience, ease of application, etc., but other systems have been used. For instance, one system calls for a first coat of shellac which, on pine, usually raises the grain of the wood. This is sanded and then a coat of patented grey lacquer that is reduced slightly with a shellac thinner used for brush application is applied. Black, orange tints and reds have been used. One or two coats of lacquer are used, whichever may be sufficient. It has been found that this system gives some advantages, but it does not last particularly long in contact with sand. Frankly, we do not believe any other fast-drying paint system would be expected to give resistance to the abrasive action of sand particles to any definitely greater degree."

Conclusion

It is in order to list the user's expectation of a wood-pattern coating along with a description of a pattern and its function. The following is a definition of a pattern as used in the instruction of classes at Cleveland Trade School, and it is rather flexible and inclusive: "a pattern is a full-sized model made of suitable material on which provisions have been made for moulding, coring, and machining." The pattern is a tool in the hands of a moulder, used to form an impression in a sand mould which is later filled with molten metal. The corebox is a frame into which sand is tamped and the sand form is dumped on a coreplate and baked to withstand handling, action of flowing metal and pressure.

The principal wear and tear on pattern equipment is abrasive action of sand rubbing against the sides, a constant exposure to a changing humidity, and the effect it has on wood, such as dry pine, mahogany, cherry, etc. To offset the customary wear and render pattern equipment moisture proof, coatings are applied as revealed in this survey. To merit consideration, the coating should be wood penetrating, quick drying, an elastic preservative that adheres to wood, and be durable and moisture proof.

American Industry's Views

Three out of every four still prefer flake to cut shellac. The shellac flakes are "cut" by covering shellac with the solvent, allowing it to soak over night, stirring it in the morning, and thinned out to suit each man's whim, which depends on his past experience and training. The absence of scales in patternshops to weigh the shellac is probably one of the reasons for not observing a more definite or recommended procedure. Grain alcohol, as a solvent, is now little used. Solvents prepared by paint and varnish companies are rapidly replacing wood alcohol, which still enjoys a 50 per cent. hold on the market.

Lampblack, the old reliable black pigment, is losing ground to black extract, a dye that has a deeper, smoother tone with results at least equally good as those obtained with lampblack. Vermilion red is a two-to-one favourite over other shades of red. Yellow pigment is little used by pattern manufacturers. Aluminium powder, mixed into shellac or varnish, is slowly gaining favour. The use of pigments depends on the pattern buyers' specifications; lacking these, the manufacturer follows his own customary practice.

The use of oxalic acid is seldom necessary in a good grade of shellac and yet this shellac, because of its grade, would be little affected by its addition (that is, it could stand a slight adulteration). The cheap shellac is already so poor in grade that addition of oxalic acid renders it unfit for pattern use.

The use of rubber-set brushes with rubber binding for use with shellac is preferable. The use of crockery shellac containers is recommended for best service.

The future pattern coating, based on this survey, will probably be a shellac priming coat with a lacquer or varnish top-coat brushed on. The use of a spray at this time is impractical.

The A.F.A. colour standard for finishing pattern equipment is favoured in such a large number of replies to this *questionnaire* that the question merits a Paper on a revision in colour standards. The use of a natural (transparent) colour shellac or varnish for the body of the pattern which forms the bulk of it, would remove the common objection that workmanship is hard to detect through a colour. This would protect the buyer of pattern equipment as well as the conscientious manufacturer who attempts to keep in mind the welfare of the foundryman in the building of pattern equipment.

It is the hope of the authors that the purchaser of patterns will give more than cursory attention to specifications in ordering patterns. He should ask for prices on *temporary* pattern, one or no coat of coating; a *mediocre* pattern with two coats and *standard* or production pattern with three coats.

Porosity Elimination in an Aluminium Casting

By "ALUMINA."

Fig. 1 shows an aluminium casting incorporating three different thicknesses of metal—½ in. at the boss, ⅜ in. in the body, and ⅞ in. at the two parts where allowance is made for machining purposes. It will be noticed that three ingates provide entry into the mould for the molten aluminium; this number in itself was excessive, as one gate was quite ample for the weight of the casting, which was 14 lbs.

When the two outside gates were sawn off, it was discovered that sponginess occurred at the junction of the casting and the gates, a cavity ⅛ in. deep penetrating into the casting into which a piece of ⅛ in. wire could easily be inserted. This cavity was the result of a "pull" being set up by the different thicknesses

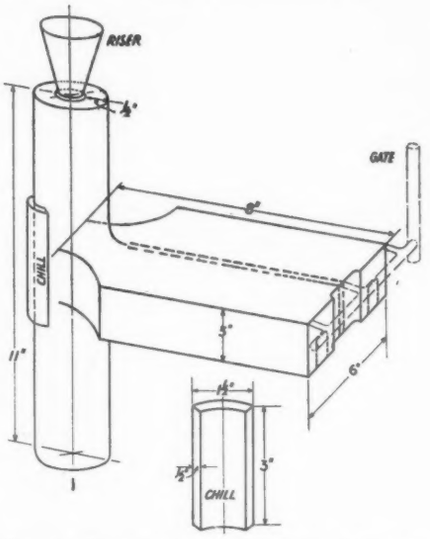

FIG. 1.—GATING ARRANGEMENTS AND CHILLING OF ALUMINIUM CASTING.

of metal not cooling uniformly. The first six castings revealed the same imperfection. The centre gate was found on examination to be quite solid, and the remaining fifty castings were poured with the one centre gate.

To ensure soundness in the boss, which had a 1½-in. core running through it, chills were employed. One was rammed up in the core where a strengthening rib connects the boss, making for a thicker section of metal where porosity would certainly occur if preventive measures were not taken. The second chill was placed against the pattern opposite the first and rammed up in the mould, both chills being positioned half-way down the boss. In addition, a riser was placed on the boss sufficiently large to ensure that it would remain fluid long enough to feed that part of the casting. The pouring temperature used for this casting was of the order of 700 deg. C.

Nasmyth Wilson & Company, Limited

Nasmyth Wilson & Company, Limited, the Manchester engineering concern, has made arrangements to dispose of its lands, building and plant, together with stocks and work in progress. The name of the purchaser is undisclosed. When the transaction is completed, the company's assets will consist of book debts, investments and cash. A full statement of the position will be submitted to a meeting of shareholders shortly. The company was formed to carry on business as locomotive and general engineers and ironfounders, but the locomotive section was sold a year or so ago.

Splitting Castings by Steel Plates*

By J. G. GOULD

No claim is made in this Paper that the method employed is original. In fact, it is a very old method and was used very much in the days of cast-iron pulleys. The technique has improved in some ways, and has been found to result in savings in patternmaking when it has been decided to split castings previously made in one piece. Another saving is in avoiding machining where a split joint is satisfactory.

One must first realise that the heavier the casting, the better are the chances of success. This is due to the slightly lower heat of the metal. Castings weighing 10 tons have been

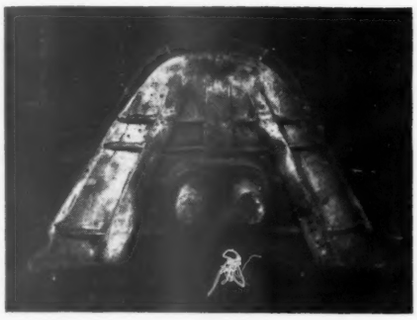

FIG. 1.—EXTERIOR VIEW OF "HALF" CASTING, AFTER SPLITTING AND DRESSING.

made quite regularly with very little trouble. Care must be taken regarding the position of the ingates, to prevent fusion of the splitters. The ingates should be of generous size, as trickling of the metal tends to buckle the plates. Another point is to fill the mould as quickly as possible, to enable any gases generated next to the joints to be evacuated before the metal sets. The plates should be arranged with a small amount of print, as it follows that a cold edge tends to buckling. The plates need supporting by spikes driven into the moulds, but the spikes should be arranged to be covered by the metal, except at the point of contact.

FIG. 2.—INTERIOR VIEW OF THE CASTING SHOWN IN FIG. 1.

Balancing gates are necessary. These may be between the ends of plates, or may be cut from the plate edge, or else may be made beyond the plate as part of the mould. The reverse of dovetail shape should be used when the cut is in the plates, to enable the easy removal of these. In the case of green-sand moulds, cold, well-mixed sand is essential, as any steam tends to settle on the plates and so cause bubbling of the metal. Dried moulds enable the plates to be kept warm, so avoiding this fault. The plates, having been warmed, are washed with a varnish made of good-quality shellac dissolved in methylated spirit, and mixed thoroughly with a good plumbago. No attempt should be made to use substitutes or inferior materials, as failure is practically certain. A second coat is given and, in cases of doubt, a third. This is quite a quick operation, as the varnish dries rather rapidly. Finally, harden off in the stove, taking care not to burn the wash.

If the plates are to be used in the job, such as is done in hopper rings or gear wheels, knife-edging of the plates is practised so that one line of cleavage occurs. When the plates are used as tools only, this is not done, any excess metal being removed by the fettlers. The knife-edges are kept clear of vital faces by $\frac{1}{4}$ or $\frac{1}{2}$ in.

One remarkable result of using steel plates is the conversion of these plates from being mild steel to a form of blister steel, which may be quite easily broken. To prevent unsightly chipping on some castings, small holes are drilled from the face of the casting to meet the edge of the plate. The writer has split castings weighing 10 tons, the joints of which were about

FIG. 3.—THE OTHER HALF OF THE LADLE CASTING BEFORE DRESSING BUT AFTER SPLITTING. IT SHOWS THE UNDISTURBED CORE.

18 ft. by 8 in., without trouble. Three plates were used.

Another interesting job was half-cylindrical castings. These were made in loam, being swept eccentric. Allowance was made for the removal of plates and also for machining. This produced two castings of identical metal, and enabled existing tackle to be used. Another series of castings had the splitting plates removed without fracturing the joints. This enables the castings to be machined without having to hold the two halves by bolting. After splitting, the joints were planed, as in this case full half-rounds were not asked for.

Sometimes doubled plates are used. The metal is allowed to fuse on to the plates, but these joints are not so good. One advantage in this case is that, when assembling the castings, all pieces are fast. If dowels are desired, the plates may be drilled with heavily countersunk holes from each side. These give an excellent grip. Should bolt holes be needed in the joints, cores may be inserted in the mould to meet the plates, or, in the case of short plates, may be put through the plates, holes having been drilled rather larger than the cores. Finally, it must not be forgotten that plates expand, and precautions must be taken to prevent damage.

* An entry in a Short Paper Competition organised by the Middlesbrough Branch of the Institute of British Foundrymen.

Mechanical Testing

MR. R. L. TEMPLIN, reviewing the progress in mechanical testing over the last 25 years, states that many of the problems which confronted the testing engineer 25 years ago are still unsolved.

Concerning 1915, Mr. Templin writes that the war and its demands for materials emphasised the necessity for standardisation of testing methods so that various laboratories could obtain comparable results. The need for better testing apparatus was appreciated. Standard methods for carrying out the Brinell hardness test were in the process of being adopted, and the scleroscope was used by many industries for checking the hardness of metals.

Much progress has been made, however, in establishing satisfactory methods of testing. Definitely better testing machines, extensometers, and auxiliary apparatus are now available, and agreement has been reached on most of the nomenclature. Tensile tests of thin sheet metals are now made by the ten-thousands, in accordance with recognised standard methods. Speed of testing has rather wide limits and is still under investigation.

The autographic extensometer has come into general use for routine tension testing. By the use of such apparatus it is now possible to obtain close agreement in yield point and yield strength among different laboratories.

Fatigue testing is being done by many laboratories, scattered throughout the U.S.A., equipped to make various kinds of tests. Endurance limits of many of the commonly used metals are now well known. The fatigue resistance of riveted and welded joints and of structures is being investigated. While the Charpy and Izod impact tests are still used, the tension-impact test is being recognised as of more value. Impact tests of built-up structures have become more common. The Rockwell hardness tester has come into general use, and many combinations of penetrators and loads are recognised as standards for various purposes.

In general there is greater uniformity and less controversy between producer and consumer because of standardised methods and procedures for routine testing. Calibration devices as well as standard methods of calibration are now in general use for testing the apparatus.

The effects of creep, the damping characteristics of materials, and the behaviour of built-up structures under static and dynamic loads are perhaps the most outstanding problems confronting the testing engineer to-day.—"Metal Progress."

Control of War Production

The Ministry of Supply issued on June 10 the Control of War Production (No. 1) Order, 1940, under which some 1,500 firms are declared controlled undertakings. The names of these firms will not be published, but a letter will be sent to each firm informing them that they are "controlled undertakings." These firms will be subject to directions issued by or on behalf of the Government Department for which they are working, usually the Admiralty, the Ministry of Aircraft Production, and Ministry of Supply.

Mr. Herbert Morrison, Minister of Supply, wants all those who are working for controlled undertakings to know that they are now in fact working for the Government, but at the same time he wishes to repeat that where existing managements are doing their job well with public spirit and efficiency, he wishes to interfere with the working arrangements as little as possible. Directions have been given to those firms included in the Order to continue with their work in accordance with existing arrangements until they are instructed otherwise. It is hoped that all firms will follow those directions and will refrain for the present from making inquiries relating to the method of control.

Melting and Casting of Copper

In a Paper on "The Effect of Atmosphere during Melting and Casting of Copper," which was presented to the Institute of Metals by MR. CARLE R. HAYWOOD, MR. MASANABU ISAWA and MR. EUGENE M. THOMAS, the following conclusions were drawn:—

There is no serious conflict between the results obtained in this work and those presented by Allen and certain other investigators, as far as the behaviour of hydrogen is concerned. It has been shown that when present in considerable concentration in the furnace atmosphere, hydrogen is readily absorbed and will cause a porous billet when the metal is cast fairly rapidly in a mould filled with hydrogen. When the hydrogen-treated metal is cast in air, the porosity of the billet is increased as a result of reaction between hydrogen and oxygen. This is probably mainly a secondary reaction, the oxygen forming cuprous oxide which in turn reacts with hydrogen. This delayed evolution of gas produces serious swelling of the billet head.

For short periods of time, moderate concentrations of hydrogen in the furnace atmosphere have little effect on the soundness of billets cast in inert or reducing gases. No tests were made to study absorption over periods of time beyond 15 minutes, although it seems reasonable to suppose that the effect of time would be an inverse function of hydrogen concentration.

The effect of carbon monoxide in the furnace atmosphere on unsoundness is negligible if the copper is to be cast under reducing conditions. If cast in air, there may be a reaction between carbon monoxide and cuprous oxide or atmospheric oxygen to cause some porosity. Since carbon dioxide is reduced to carbon monoxide when the copper has a charcoal cover, it is obvious that carbon dioxide in the furnace atmosphere may be neglected.

The influence of sulphur dioxide is of great importance. It readily dissolves in, and reacts with, molten copper during casting; in the presence of a charcoal covering on the molten copper in the furnace it is reduced to sulphur which reacts with the copper to form cuprous sulphide. If the copper containing cuprous sulphide is cast under reducing conditions, this compound remains as such in the metal and a sound billet is produced, but if the copper is cast in air the cuprous sulphide reacts with atmospheric oxygen or cuprous oxide and sulphur dioxide is evolved, producing unsoundness.

When copper, melted under charcoal and therefore very low in oxygen, is poled with green twigs, the billets produced are very unsound. The nature of the gases was not determined, but in view of the known conditions and the results of other tests, it is fairly safe to assume that the unsoundness is due to hydrogen.

Other investigators have shown that nitrogen has little or no solubility in copper and may be used to displace other gases. This was confirmed in the present tests. It was further shown that the introduction of an atmosphere of nitrogen over molten copper in which large amounts of hydrogen are dissolved is sufficient to allow the hydrogen to diffuse out of the copper to a point where a sound billet will be produced if cast under reducing conditions.

One of the most interesting observations in the above tests was the rapidity with which oxygen is taken up by the copper during casting. In the very short interval during which the copper was running from the crucible to the mould, the oxygen had an important effect on it, and made the difference between up to two bends after the hydrogen anneal, and 10 to 12 bends. This rapidity of attack was also noted in the case of sulphur dioxide. Since the copper was cooling rapidly, hydrogen in the mould was not absorbed.

From the above observation the following comments on copper refining operations seem justified:—

(1) When the oxygen becomes low in the copper, the bath will absorb considerable quantities of hydrogen, either directly from the furnace atmosphere and the poles or through reduction of water vapour from the atmosphere and poles by hot carbon. There will be some, but considerably less, absorption of carbon monoxide, either directly from the furnace atmosphere or through reduction of carbon dioxide by hot carbon. There may be some absorption of sulphur dioxide, but most of the gas will probably be reduced to sulphur by hot carbon and form cuprous sulphide. The sources of sulphur are the furnace atmosphere, the charcoal or coke, the cathode copper, and the poles.

(2) If low-oxygen copper, produced in the usual way in fuel-fired reverberatory furnaces and reduced by poling, is cast under oxidising, reducing, or neutral conditions, it will always be unsound owing to the large amount of dissolved gases; the unsoundness will, however, be greater when it is cast in air, due to the formation of cuprous oxide, followed by its partial reduction by hydrogen and carbon monoxide.

(3) The principal source of hydrogen in the copper is undoubtedly the poles. It might be possible to eliminate a considerable part of it by allowing the copper to stand for a period after the poling is completed, to give time for diffusion of hydrogen from the bath to the furnace atmosphere. Decreasing the temperature would also be helpful.

(4) Melting cathodes by continuous feeding beneath the bath in an electric furnace without poling should give a minimum of gases in the molten copper, and casting under reducing conditions in a manner similar to that used by the producers of O.F.H.C. copper should give maximum soundness and minimum oxide content. Even the small amount of air in the mould should be displaced if the best results are to be obtained.

(*Continued from third column.*)

a wise choice, which systematically covers the copper, aluminium, lead, tin, zinc and nickel base alloys.

The final section is devoted to cast iron, and includes white as well as grey iron. The remarks made about whiteheart malleable and its potentialities in the American market could be very well paralleled to the almost complete dearth of "chilled car wheels" in this country. Apparently something of the order of 750,000 tons is the annual American consumption of the commodity. No fewer than eighteen pages are devoted to setting out the compositions of specific applications of alloy cast irons, a feature indicative of the great strides foundry practice is making in America.

Though this is a committee publication, much credit must be given to the permanent staff of the A.F.A. for the assembly and presentation of such a mass of valuable data. Throughout the whole of the text there is a welcome absence of ambiguity or badly-constructed sentences, and it can be said that it reaches the highest standard of American technical literature.

V. C. F.

Book Review

Cast Metals Handbook (1940 Edition). Published by the American Foundrymen's Association, 222, West Adams Street, Chicago, Ill., U.S.A. Price 5 dollars.

When the first edition of this book was published in 1935, it was deemed of such importance by the Editor that a leading article was written instead of a formal review. The second edition is every bit as important, as the revision has been both extensive and thorough. Moreover, there is a guarantee that the future will see that the high standard of the book is maintained, for when the third edition is released it will be available to registered buyers at three dollars, providing they return their obsolete copies.

The handbook is the work of four committees, representing grey-iron, steel, malleable and non-ferrous foundry interests. It should be clearly understood that the book is written mainly for engineers and designers, so that any particular section may appear somewhat elementary to the foundry specialist. Despite this, however, he will find much of interest in other divisions of the book.

As is logical the book opens with specific recommendations to designers of castings and introduces the reader to the types of pattern normally used; shrinkage and machining allowances; tolerances, and minimum sections for various cast alloys. The notes germane to actual designing, whilst excellent so far as they go, still require extending because the greater the help the foundryman can give in this direction the higher will be his ultimate reward. It is for the leaders of foundry thought to place stepping stones in the stream of ignorance for it is rare to find the pioneering instinct amongst designers, who by their very training think in factors of safety.

The present edition contains an entirely new feature written by Prof. H. F. Moore on "The Significance of Strength and Ductility Tests of Metals." From it is culled the following quotation, as it could usefully form the subject of debate in certain British steelfoundry circles: "The significance of a notched-bar test seems to be the determination of sensitivity of a metal to notches and stress raisers rather than the toughness of the metal itself."

From the British point of view the section devoted to steel castings—the heading is "Cast Steel," which term in this country has been appropriated by the makers of steel by the crucible process—is the best of four main divisions. Not only does it cover a field somewhat neglected in European literature, but it also has sixteen pages devoted to design, a matter not referred to in the three others. In the bibliography which terminates the section are 83 references, and a somewhat striking omission is the absence of the Steel Castings Reports published under the auspices of the Iron and Steel Institute.

The section dealing with malleable confines itself to the blackheart variety, as apparently no whiteheart is made, and in this connection the reviewer suggests to the American foundry industry that it may be, from this fact, losing a considerable amount of business which could be reasonably attracted. Whiteheart, carrying as it does a ferritic skin, can be readily plated by standard methods to give really attractive finishes. Two quite large lines made in English foundries are harness fittings and motor-vehicle door handles, neither of which is listed amongst the uses of malleable.

The most difficult section to prepare is obviously that of non-ferrous alloys, because of the innumerable combinations available for discussion. However, the committee has made

(*Continued at foot of previous column.*)

Production of Pressure-Resisting and High-Duty Iron Castings

By J. L. FRANCIS, A.M.I.Mech.E.

This Paper was prepared for the annual meeting of the Institute of British Foundrymen, and written discussion is invited. Contributions should be sent to Mr. J. Bolton, Institute of British Foundrymen, St. John Street Chambers, Deansgate, Manchester, 3

The foundry with which the author is associated is not laid out for production of large numbers of standard castings. It is essentially a jobbing foundry wherein the few-off job is the rule rather than the exception. Mechanisation is, therefore, not readily applicable to any great extent. Tackle and equipment must be designed so as to allow of the maximum elasticity in use, that is, so that it may be adaptable to various jobs, not specialised for one single purpose, as is done with advantage where quantity production is concerned.

Many things militate against the production of sound castings, even when conditions and circumstances under which they are made are normal. With the country at war, abnormal conditions prevail, making the usual difficulties greater and imposing others at a time when foundries are required to give a maximum output produced regularly to schedule. In order to prevent disorganisation of programmes, castings must pass into service with the utmost despatch. Castings which are obviously wasters on knocking out are bad; those with defects revealed only after machining are worse; but worst of all are the ones which have to be rejected after water-pressure testing, when in the majority of cases machining operations have been completed. In these times work which has to be repeated is not only a loss of time and money, but places an extra burden upon men and machinery already working to the limit of capacity.

Metal Practice

Before proceeding to deal with typical high-duty and pressure-resisting castings, the problem of providing correct metal for the work may be considered. This aspect of the matter is not least in importance or effect. Here again the point of maximum adaptability arises, and the metal practice evolved by the author has to cater for castings of diverse weight, size and type. Simplicity of operation is an asset in most spheres of activity and is particularly so with regard to founding. Consequently grades of pig-iron and scrap should be kept to a minimum and the number of different metal mixtures made as few as possible.

Type and Range of Castings

The system to be described has been worked out to embrace straight and alloyed grey-iron castings, weighing from a few ounces to 2 tons. Excepting flywheels, which are not pressure-resisting castings, the work cannot be termed heavy. Most of it enters into the medium or light category. Metal sections range between $\frac{5}{16}$ in. and $1\frac{1}{2}$ in. thick; hence the problem occasioned by excessive slow cooling of massive sections yielding coarse-grained structures is not often met. Occasionally it becomes necessary to make castings of size, weight and section beyond that stipulated, but in any case they are required for machines which for the most part must conform to exacting conditions of service.

Pistons, cylinders, liners and valve covers form a class wherein resistance to pressure and wear is of paramount concern. Working pressures in some instances rise to as high as 3,500 lbs. per sq. in. For these castings ease of machining is of secondary consideration. Intricate coring and wide sectional variations obtain to form water jackets and air spaces. Moreover, no leakage must take place between the water and air. Briefly, the castings are of just the kind most difficult to make sound and for which this property is of supreme moment.

Chemical and Metallurgical Control

Systematic working and production of standard grades of iron having constantly uniform chemical and physical properties cannot be attained without efficient chemical and metallurgical control. Indeed, such control forms part of the very foundation upon which progress in the founding of sound castings has been built up. Pig-irons and other components of the furnace charges must conform to specifications. On delivery, representative samples are taken and tested to ensure that the materials comply. Once standard analyses are established for given classes of work they should be maintained reasonably constant. Distinct grades of cast iron possessing known and reliable physical data facilitate calculations involved in design. Agreement as to the effect of design on casting soundness is unanimous, hence anything tending towards simplification of design is a good step in the desired direction.

The term "high-duty iron" used in these notes refers to material able to fulfil the requirements of British Standard Specification No. 786 (1938), which covers a tensile strength of from 15 to 22 tons per sq. in. obtained from the 0.875-in. dia. cast bar, machined to 0.564 sq. in. section.

Melting Practice

All the iron is melted in cupolas fitted with receivers. Melting practice and the selection of charge components are therefore based on this mode of production. Cost and economy must always be borne in mind in all phases of commercial manufacture, and these points have been given due consideration relative to other requirements.

Standard grades and mixings of iron suitable for special classes of castings are of little use unless the mixture charged, as distinct units, can be drawn off at the tap hole with their individuality maintained. Where circumstances permit the running of a cast with one grade of metal only, the problem is simple of solution. When the moulds to be cast for one day's work need different qualities of iron, charging and melting operations must follow a planned programme under close supervision.

A system giving good results in practice is worked as follows:—The cupolas employed hold six charges of 10 cwts. each, and the softest grade of iron is charged directly on to the coke bed, giving a double advantage. First, the softest grade, listed as No. 1 in Table II, is used to pour the less exacting castings, and, secondly, a gradual blending towards harder iron can take place. Taking a definite case, suppose two $\frac{1}{2}$-ton charges of grade 1 are placed first, followed by 10 cwts. of grade 2, which is a little harder. Two further charges of grades 3 or 4, cylinder iron, can follow, making a total of five. Table II gives another and harder grade, No. 5, which can be used with or without alloy additions. If this is needed, it follows after Grades 3 and 4, making the furnace fully charged ready for blowing to commence. Other charges wanted to complete the cast are put on as required in reverse order, so that the grades work back again to softer metal.

In practice, the system resolves into taking the quantities of the various grades required to pour the moulds prepared, and charging in the manner described. A programme is made out with the exact order in which the different castings are to be poured, the weight of iron necessary and the size of ladle to be used. Then,

TABLE I.—*Raw Materials Used.*

Material.	Mark.	Chemical specification. Per cent.					Remarks.
		T.C.	Si.	Mn.	S.	P.	
Pig-iron	A	3.25 to 3.50	3.50 to 4.00	1.75 to 2.00	0.04 max.	1.00	Soft foundry.
Do.	B	3.50 to 4.00	2.50 to 3.00	0.75 to 1.00	0.03 to 0.04	0.25 to 0.50	Scotch.
Do.	C	3.00 to 3.25	1.25 to 1.50	1.25	0.05 to 0.07	0.50 max.	Cylinder.
Do.	D	3.00 max.	1.00 to 1.30	1.25 to 1.50	0.06 to 0.08	0.50 max.	Refined.
Do.	E	3.00 max.	1.80 to 2.20	1.25 to 1.50	0.06 max.	0.45 max.	Refined.
Foreign scrap	F	3.50	2.00	0.50	0.10	0.75	Average composition.
Returns: Grades 1 and 2.	G	3.30	1.80 to 2.25	0.80	0.08	0.80	Composition varies according to proportions, Grades 1 and 2
Returns: Grades 3, 4 and 5.	H	3.10	1.45	0.85	0.10	0.50	Composition varies according to proportions, Grades 3, 4 and 5.
Alloyed returns ..	J	3.10	1.45	0.85	0.10	0.45	Alloy content according to additions made.
Steel scrap	K	0.30	0.10 to 0.20	0.50	0.05	0.05	Average composition.

when melting is in progress, no time is lost in making decisions of this nature; confusion also is avoided. Time is a very important factor in gauging the grades as they come down. Unless the whole business is worked strictly to schedule, it becomes a muddle.

The timetable is based on a constant melting rate, which is obtained through a standardised method of cupola operation. Regularity of charging and melting must go on without a hitch; therefore, reasonable uniformity in size of pig and scrap is important. Hanging up of the furnace distorts the timing and the charging of an extra coke split has a similar effect. Thus, the practice of separating grades of metal by heavier coke charges is not satisfactory.

After melting is properly under way in the cupola previously mentioned, that is, after the first three charges, 10 cwts. of iron are melted every 7 min. Having established a constant rate of melting and the placing of charges in an arranged order, it is possible to tell exactly the stage reached at any point during the blow, the grade of metal which is melting and how much more may be expected. The presence of someone responsible for this timing is necessary throughout the duration of the melt. Likewise, too, the men who weigh out and load the charges must be trained and trustworthy.

By the practice of timing the melting of the charges and tapping at the end of completed periods, the danger of splitting a charge, thereby getting a wrong mixture, is prevented. Only complete charge units should be tapped. Some of the work may require casting from small hand shanks. These ought not to be caught when the furnace is dry, as most irregular results come from so doing. One or more complete charges should be present in the receiver or well of the furnace.

Selection of Charge Components

Specified compositions for five pig-irons and chemical analysis of foundry returns and bought scrap are included in Table I. Apart from ferro-alloys, these items are sufficient to provide the grades of iron shown by Table II, which gives as well an idea of their purpose and the minimum tensile and transverse strengths capable of being produced.

Total carbon content has a pronounced bearing on soundness. Pig-irons of hyper-eutectic composition are not suitable for direct use in producing high-duty iron castings. Hematites are not favoured for this reason. It will be noted that all the materials listed in Table I have carbon equivalent values at or below the eutectic value of 4.3 per cent., excepting item B. Two of the pig-irons, D and E, are of the refined type and reserved for use in the highest-grade mixtures. Leaving out of account thick-sectioned work of 2 in. and over, the most satisfactory total carbon content lies between 3.1 and 3.3 per cent. Values between these limits yield strong metal of close grain with reasonable machining qualities.

To keep within this range the carbon content of the charge materials must be restricted to under 3.5 per cent. for high-duty compositions, unless high percentages of steel scrap are included to dilute it. Steel scrap up to 10 or 15 per cent. of the total charge may be incorporated with advantage and no modification of the normal melting practice. Larger proportions require special precautions in melting, and when used with other pig and scrap for direct pouring into moulds, troubles due to shrinkage and heterogeneity of the product are likely to be experienced.

TABLE II.—*Material Covered by the Paper.*

Grade.	Cupola charge. Per cent.	Chemical analysis. Per cent. T.C.	Si.	Mn.	S.	P.	Physical tests. Tensile (Tons per sq. in)	Transverse (Tons per sq. in)	Suitable to meet specification.	Suitable for casting.
1	30 A 30 F 40 G	3.3	2.3	0.75	0.08	0.85	12.0	24.0	B.S.I. No. 321(1938) Grade "A." 0.875-in. dia. bar.	Bedplates, standards, pulleys, machine tools, small details and fittings to withstand no wear. General-purpose castings of light section.
2	15 B 15 D 20 F 40 G 10 K	3.25	1.70	0.70	0.08	0.65	14.0	25.5	British Admiralty, 13 to 14 tons per sq. in. 0.875-in. dia. bar	Flywheels, crankcases, covers, gearcases, small compressor bodies, cylinders where liners are fitted. Medium-sectioned castings not required to withstand high working pressure.
3	25 A 25 D 40 H 10 K	3.20	1.65	1.0	0.10	0.55	15.0	26.5	B.S.I. No. 786(1938) Grade I, also British Admiralty, 14 tons per sq. in. 0.875-in. dia. bar.	Cylinder covers, heavy flywheels, pistons, steam cylinders, parts in sliding contact and all castings similar to above needing a tighter metal giving more wear and pressure resistance.
4	20 C 30 E 40 H 10 K	3.0	1.4	0.95	0.10	0.45	16.0	28.0	B.S.I. No. 786(1938) Grade I, also British Admiralty, 16 tons per sq. in. 0.875-in. dia. bar.	Cylinder liners, H.-P. covers, rotors, crossheads, water-jacketed castings and castings of heavy section to meet heavy wear and pressure conditions.
5	20 E 30 C 40 H 10 K	3.0	1.15	1.0	0.10	0.45	17.0 Higher tests with alloy additions.	30.0	B.S.I. No. 786(1938) Grades II and III, 0.875-in. dia. bar.	Castings as above and those required for specially severe working conditions.

Total Carbon

Much has been done and published about the effect of total carbon content on cast irons, and its fundamental influence is widely recognised. As already stated, it must be controlled for high-duty castings. For work within the range of sectional thickness quoted, the limits mentioned are satisfactory, and can be maintained regularly without great difficulty or highly specialised cupola technique, providing T.C is not present to excess in the materials charged. Charge materials having excess of coarse graphite tend to retain this characteristic even after passage through the cupola.

The charge coke is the greatest source of carbon entering the cupola, and to limit carbon pick-up it must be dense, of suitable quality and not charged greatly in excess of the quantity necessary to provide heat for melting and superheating the iron. Indeed, a study of the correct coke ratios for the bed and between the charges forms an essential factor in obtaining satisfactory high-duty castings.

Upon the quantity of coke to be burned depends the volume of the air blast. With uniform blast volume, coke splits and metal charges, total carbon pick-up increases with height of coke bed. It also increases with increase of coke splits, blast volume and bed charge remaining constant. Blast volume should remain uniform throughout the blow. Raising the air volume tends to burn away the coke from the charges above the melting zone, with the result that the bed becomes lowered and metal charges melt too near the tuyeres.

Fast melting and removal of the iron from the coke bed minimises carbon pick-up. Receivers are advantageous from this point of view, and also because they allow of the tuyeres being placed nearer the base of the furnace, thus reducing the height of coke in the bed.

Although control of the total carbon ratio is a major factor in the manufacture of successful high-duty iron castings, it is not sufficient to consider it without taking into account the influence of silicon and phosphorus at the same time. The range of carbon given above applies where these two elements are restricted to within certain proportions. Pure iron-carbon alloys solidify at steadily decreasing temperatures until the eutectic composition is reached at 4.3 per cent. carbon. When silicon and phosphorus are introduced, they have the effect of reducing the amount of carbon for the alloy of lowest melting point. It has been found that the reduction of carbon is 0.3 per cent. for each 1.0 per cent. of silicon, and 0.3 per cent. also for each 1.0 per cent. of phosphorus present. Consequently an iron with 1.0 per cent. each of silicon and phosphorus reaches the eutectic composition with 3.7 per cent. total carbon. Any carbon above this amount tends towards excessive graphitisation under normal conditions of cooling.

A convenient method of evaluating cast irons with respect to their eutectic condition has been suggested by the B.C.I.R.A. It consists in calculating the "carbon equivalent" value, which is the percentage of total carbon actually found to be present, plus the carbon equivalents of the silicon and phosphorus contents as mentioned. Thus, if the iron quoted above with 1.0 per cent. each of silicon and phosphorus had also 3.3 per cent. total carbon, its carbon equivalent value would be 3.3 plus 0.6, or 3.9 per cent. Incidentally, the author has found that as a general rule no composition of grey cast iron is likely to fulfil the definition for high-duty material unless the carbon equivalent value derived as explained is kept below 3.9 per cent.; a useful range is from 3.6 per cent.

Shrinkage Defects

Rejects resulting from shrinkage in one or other of its forms are a trouble particularly in evidence with castings of high-duty iron. It is an unfortunate fact that the higher-quality irons exhibit a greater tendency towards shrinkage during solidification because the expansion due to graphitisation is not so great as in high-carbon grey irons, and the liquid contraction is not counteracted to so great a degree. For this reason, it is desirable to maintain total carbon ratios at as high a level as possible consistent

with high-duty properties, and the metal practice outlined has been instituted with this point in mind.

Actually the amount of liquid shrinkage which must occur is not altered much by chemical composition. Casting temperature exerts the predominating effect, and high-duty irons need to be cast hot, since their range of fluidity is not so great as that of soft phosphoric irons.

Shrinkage defects have been classified under four headings:—(1) Piping; (2) sinking; (3) porosity; and (4) cracking and warping. Although all are due to the inevitable volume changes which occur during the transition from the high-temperature liquid phase to the solid phase at atmospheric temperature, they are controlled to some extent by temperature of metal when poured, casting design, composition of metal and the mould conditions, particularly with respect to size and placing of runners and risers.

Piping is not very prevalent in grey-iron castings unless they are very massive indeed. Sinking is more often found and may be regarded as incipient piping. Porosity is the main anxiety with pressure-resisting castings, oftentimes not revealed until the hydraulic test is applied.

Phosphorus and its effect on porosity have provided a basis for much discussion. There is no doubt that substantial percentages increase the range over which solidification takes place. For pressure-resisting castings of complicated design with ribs, bosses and abrupt changes of section, it is better to restrict it to around 0.3 per cent. Such castings have many places where feeding is impossible to apply. Thick sections naturally cool slowly with predisposition to formation of coarse grain and porosity. Therefore it is logical to avoid a composition which will allow these places to contain liquid metal longer than is necessary.

Some authorities think that the *rôle* played by phosphorus in causing porosity is overemphasised. They invariably quote instances of castings containing appreciable amounts of it which have not shown any trace of porosity and have, moreover, functioned perfectly in service. Whilst it is not possible to refute such evidence, at the same time the instances brought forward, upon examination, often turn out to be of a type or design such as would not be highly susceptible to the defect which high phosphorus content helps to cause. Certain types of casting do benefit from the presence of phosphorus, but the high-duty casting for pressure resistance is certainly not one of them.

Work carried out by the B.C.I.R.A. confirms that the type of shrinkage defect depends on the proportions of silicon, carbon and phosphorus in the metal. An increase in one or all of these elements assists in bringing about porosity and by correct regulation the tendency may be considerably lessened. The conclusions reached were that, with silicon at 1.5 per cent. and phosphorus greater than 0.25 per cent., total carbon must not exceed about 3.4 per cent. Similarly, with 2.0 per cent. silicon, the limit for total carbon is at 3.2 per cent., and for 3.0 per cent. silicon at around 2.7 per cent. Silicon and phosphorus are easier to control with cupola melting than is total carbon, so that metal analyses should be adjusted along these lines.

High Manganese Content

A study of Table I will reveal the fact that all the pig-irons contain manganese in amounts beyond the average. The idea is to arrange the charges so that a manganese content of between 0.75 and 1.0 per cent. is present in the castings. From experience gathered during 20 years the author is convinced of the benefits to be derived from manganese up to this amount, particularly for castings of the high-duty type. He has dealt at length with this subject elsewhere.[1] Other workers[2 3 4] have written on the subject also.

Briefly, manganese assists towards the production of sound castings by combining with the sulphur. To ensure an absence of iron sulphide, an excess of manganese beyond the theoretical quantity for chemical combination with the sulphur is needed. Norbury has suggested a minimum ratio of 1.7 times the sulphur content plus 0.3 per cent., which works out at 0.47 per cent. manganese for a sulphur content of 0.1 per cent. By adopting this practice, the iron is less likely to form hard or chilled edges. A surplus of manganese above that required by Norbury's formula is advisable as melting losses may reach 30 per cent. Apart from this, manganese helps to increase fluidity, shortens the freezing range and gives a closer-grained iron, so that the more manganese there is present—at any rate up to 1.0 per cent.—the less tendency exists for shrinkage to occur as draw-holes.

Alloyed Cast Iron

Additions to cast iron of elements such as copper, nickel, chromium and molybdenum have done much to widen its field of usefulness by imparting new properties. For most applications, ruling out the highly alloyed special cast irons, the combined or total alloy additions are not required in excess of 2 or 3 per cent., quantities which allow of introduction directly to the molten iron in the ladle. Special combinations of the alloy metals are available, so arranged that an exothermic reaction results and no temperature drop is caused.

The five grades of cast iron set out in Table II are of themselves enough for many and varied casting requirements. Suitable ladle additions to either grade 4 or 5 will extend the range considerably and include castings for internal-combustion engines, Diesel-engine liners, brakedrums, heat-treatable cast iron and iron for chilled castings.

Several advantages accrue from the addition of alloys direct to the melt in the ladle as opposed to their incorporation as such in the cupola charge. Chromium is subject to a substantial loss in passage through the furnace and forms a very refractory slag. Moreover, accurate determination of the amount to be used for a definite percentage in the casting is difficult as the degree of oxidation varies.

Nickel is not subject to oxidation and loss in the furnace like chromium, but here again ladle additions are more exact, confining the alloy to a given volume of metal. Much more latitude in working is possible, as charges can be alloyed differently from one to another, as the castings to be poured may require, without any alteration to the basis charges entering the furnace.

To summarise, ladle additions are more precise, suffer the minimum wastage of alloying elements, ensure that the alloys are just where required, and, providing proper precautions are taken in making the additions, no troubles from lack of solubility or homogeneous mixing arise.

Pressure-tightness and good wearing qualities are main characteristics striven for in the castings described here. For these properties nickel alone or in combination with copper suffices to render thick sections dense and sound and maintain thin sections grey and machinable. Alloying is accordingly restricted to the use of these two metals in the majority of cases.

A point which will stand emphasis is that for receiving alloy additions a good base iron is desirable. Ferro-alloys are expensive materials, and they should be utilised to the maximum advantage. It is possible to load up an ordinary soft iron with alloys until it meets the high-duty specification, but this is an uneconomical use of alloys. They should be reserved for use with a good base iron and not in an attempt to make a poor iron into a fair one. Another factor to remember is the need for adjusting the composition of the base iron to suit the additions being made. Most of the elements used for alloying have a plus or minus silicon equivalent which must be allowed for in order to get optimum results.

Segregation of Returned Scrap

Iron returned from the foundry for remelting is kept to its separate grades, as indicated in Table I. By so doing, alloy-bearing scrap is available for re-use in similar mixtures and the new additions needed subsequently will be less in proportion to the quantity already there. Care over this matter ensures that alloyed material does not contaminate mixtures where it is not wanted, although nickel and copper in small amounts cannot do harm to any composition.

Table II shows that "foreign" or bought cast-iron scrap F is employed in the two lowest grades 1 and 2 only. Its chemical analysis is not known definitely; thus it should not be employed in charges for high-duty castings. Runners, risers, etc., from grades 1 and 2 are collected and stored separately to form item G of Table I. Likewise, returns from grades 3, 4 and 5 are gathered together under H. The remaining classification J represents the alloyed returns previously mentioned. Segregation of the scrap returns in this way helps considerably in maintaining that regularity of product stressed above. It also contributes in no small degree towards soundness. Another valuable attribute of the grading and separation of returns exists in the knowledge of its chemical constitution. Regular check analyses on the grades melted ensure this, making it a constituent of known effect, and in this respect equal to pig-iron. Allocation of the proportion of foundry returns used in the charges is such that a balance is struck between production and consumption, ensuring neither excessive accumulation nor shortage.

(*To be continued.*)

REFERENCES.

[1] J. L. Francis, FOUNDRY TRADE JOURNAL, June 15, 1933, p. 416.
[2] A. L. Norbury, FOUNDRY TRADE JOURNAL, Aug. 1, 1929, p. 79.
[3] H. H. Shepherd, "Metal Industry," Feb. 5, 1926, p. 138.
[4] P. A. Russell, FOUNDRY TRADE JOURNAL, Jan. 26, 1928, p. 66.

Catalogue Received

Gas-Fired Unit Heaters. Catalogue No. V181 issued by Keith Blackman, Limited, of Mill Mead Road, London, N.17, describes and illustrates a line of low-pressure, gas-fired warm air units. The unit incorporates a 15-in. dia. propeller fan with an electric driving motor, screen protected luminous flame burners, and an automatic lighting and extinguishing device. These units are designed for installing at a height of 14 ft. in factories and workshops, no flues being necessary as combustion is complete. The design is such that in central positions the warm air is sent downwards in cone formation. In corner positions, however, louvres are incorporated to give directional control. Full instructions for fixing and operating are included in this catalogue, which is available to readers on writing to Mill Mead Road.

Chromium Heat-Resisting Cast Irons

(*Continued from page* 464.)

is great danger of the scaling and growth being greater than the corresponding unalloyed iron. The introduction of a high-chrome : high-silicon iron gives less scaling and much less growth. The body of these castings may operate up to 650 deg. C. and the needles in the gas stream are up to 850 deg. C. at their tips.

The tests on which these compositions were standardised were carried out some years ago and modified slightly to aid the production of a high percentage of good castings. Recent tests have shown, however, that the modification has led to slight improvement in growth resistance.

(*To be continued.*)

The Week's News in Brief

Trade Talk

EXTENSIONS and reconstruction are to be carried out by the Horne Engineering Company, Limited, at Maryhill, Glasgow.

BINNEY & SMITH & ASHBY, LIMITED, of 17, Laurence Pountney Lane, London, E.C.4, are now in a position to supply kieselguhr of Portuguese origin.

RICHARD THOMAS & COMPANY, LIMITED, have left their emergency quarters at Cobham, Surrey, and have returned to their London offices in Shell-Mex House, Strand.

J. H. FENNER & COMPANY, LIMITED, announce that, as from June 10, their "V" rope sales department will be located at their works at Beck Lane, Heckmondwike, Yorks.

LAKE & ELLIOT, LIMITED, of Braintree, have just concluded an arrangement with the Essex Education Committee whereby extension classes are to be held at the works on Saturday mornings and two evenings a week for the benefit of the employees. This action is due to the curtailment of normal education.

THE GEORGE BENNIE RAILPLANE, which was constructed at Milngavie, near Glasgow, 10 years ago, for demonstration purposes, is to be scrapped and the metal—about 100 tons—salvaged. It was claimed that the Railplane could travel from Glasgow to Edinburgh—some 40-odd miles—in 20 minutes.

THE CARBORUNDUM COMPANY, LIMITED, Trafford Park, Manchester, manufacturers of abrasive and refractory products, have appointed Mr. R. Douglas Robin, of 17, Broom Road, Newlands, Glasgow, S.3, as their representative in the Glasgow and South-West Scotland Area, in succession to the late Mr. Gordon D. Hardie.

THE GIFT of Colvilles, Limited, a rehabilitation clinic was declared open by Mr. John Colville, M.P., at Glasgow Royal Infirmary last Friday. The function of the clinic, which cost £10,000, is the treatment of fractures and the gift commemorates the visit of the King and Queen to the Clydebridge Steelworks, Cambuslang, in May, 1938. A plaque commemorating the gift was unveiled by Mrs. Craig, wife of Mr. John Craig, managing director of the company, who was also present at the ceremony.

THE COUNCIL of the Institute of Welding have made the following nominations for the offices which become vacant for the session 1940-41:—*President*, Sir William J. Larke. *Vice-Presidents*: The Rt. Hon. the Earl of Dudley; the Rt. Hon. Lord Sempill; Commander Sir Charles Craven; Sir James Lithgow; Mr. G. E. Bailey; Mr. A. Dorman; Mr. Ralph Freeman; Dr. J. H. Paterson, and Mr. W. W. Watt. *Honorary Treasurer*, Mr. W. R. J. Britten. *Members of Council*: Mr. J. L. Adam; Sir Clement Hindley; Mr. W. A. Stanier; Mr. K. P. Strohmenger; Mr. G. G. Parker; Major C. P. N. Raikes; Mr. R. O. Skeggs; Dr. A. G. C. Gwyer, and Mr. A. Stephenson.

THE POWERS of the Home Secretary under the Factory Acts are to be transferred to the Minister of Labour and National Service for the period of the war. Mr. Bevin has now established in the Ministry of Labour a Factory and Welfare Department, of which the Factory Department transferred from the Home Office forms a part, for the purpose of carrying out the new duties imposed upon him. This department will work in close co-operation with the Industrial Health Research Board, local authorities, trades unions and employers' organisations, and voluntary organisations dealing with the various aspects of the safety, health and welfare of men, women and young persons engaged in industry. The Minister has established a Factory and Welfare Advisory Board, of which he is chairman.

MORE THAN 100 technical Papers and reports are scheduled for presentation at the 1940 (Forty-third) Annual Meeting of the American Society for Testing Materials, to be held from June 24 to 28 at Chalfonte-Haddon Hall, Atlantic City. In the 22 sessions comprising the programme, there will be outstanding contributions on various topics involving engineering materials, committee reports covering particularly standardisation and testing. Outstanding items of the programme include the annual address of the President (H. H. Morgan) on the subject "Standard Specifications for Materials and Their Commercial Importance"; the Fifteenth Edgar Marburg Lecture, by P. H. Bates, on "Portland Cement—Theories (Proved and Otherwise) and Specifications," and a symposium on the significance of the tension test in relation to design. In spite of the universal use of the tension test, there are still certain differences of opinion regarding the significance of the results obtained, and in view of the increased activity in developing codes for working stresses on the part of designing engineers, in which tension test results play an important part, it has seemed fitting to attempt to co-ordinate various viewpoints regarding strength and ductility. The symposium will consist of three formal technical Papers covering the general aspects of the tension test, the strength, and also the ductility features. In addition, other sessions will cover cast iron and malleable iron castings.

A COMMISSION appointed recently to survey the industrial requirements of South Africa has issued an interim report recommending acceleration of work on new steel plant; investigation into means of increasing coke supplies with a view to building up a large stock of pig-iron; increased production of fuel; inquiry into hydrogenation processes; and expansion of the explosives manufacturing industry. It is because of the likelihood that steel supplies will become more difficult to obtain from overseas as the war intensifies that the Commission recommends an expansion of steel plant and measures to augment coke supplies. The Union's ingot capacity will be increased by approximately 100,000 tons next year, when new plant at the Iscor works comes into operation. This will bring the total capacity up to about 540,000 tons annually, comprising roughly 412,000 tons of finished products, or 40 per cent. of South Africa's pre-war requirements. According to information supplied to the Commission it has been decided to extend the Union's steel production further by over 250,000 tons of ingots a year, raising the total output to about 800,000 tons of ingots, or 600,000 tons of finished products. Construction of this new steel-making plant has already been commenced, it is added. Mr. G. D. Louw, of the Department of Commerce and Industries, stated recently that the aggregate maximum output of billets, blooms and sheet bars of all steelworks in the Union was only about one-third of the country's consumption. This production was, in itself, almost entirely dependent upon the output of the three blast furnaces in the Union—namely, the two at Iscor and the third at Newcastle. Scrap steel was also used, but the supply was very limited.

New Companies

(From the Register compiled by Jordan & Sons, Limited, Company Registration Agents, 116 to 118, Chancery Lane, London, W.C.2.)

British Iron & Steel Corporation (Scrap), Limited—Buyers, sellers, importers and exporters of and dealers in scrap metals, etc.

United Carborundum Grinding Wheels, Limited—Capital, £200. Directors: H. A. Allman and T. J. Ball, 8, The Avenue, Lincoln.

Milford Engineering Company (Huddersfield), Limited, Central Ironworks, Huddersfield—Capital, £5,000. Directors: B. L. Broadbent and W. Hallitt.

British Iron & Steel Corporation (Salvage), Limited—Capital, £1,000. To acquire ships and vessels for improving, re-selling or breaking up, and to carry on the business of salvors, salvage ship owners, etc.

Contracts Open

East London, S.A., July 10—Cast-iron pipes and fittings, for the Municipality of East London. (D.O.T. reference: T. 19,887/40.)

Kirkham, June 28—Provision and laying of some 4,000 yds. of 24-in. spun-iron pipe sewer, and 376 yds. of similar sewers, 18 in. in dia., together with the necessary manholes, for the Kirkham Urban and Fylde Rural District Councils. Mr. F. Pickup, clerk to the Kirkham Council, Council Offices, Kirkham, Lancs. (Fee £5 returnable.)

Personal

MR. ALEXANDER S. MACLELLAN has been appointed Director-General of Ammunition Production in the Ministry of Supply.

MR. ARTHUR CROSS, President of the Dominion Steel & Coal Corporation, Limited, of Canada, has been elected a director of Canada Iron Foundries, Limited.

MR. J. H. KEMP, chairman of Fletcher Russell & Company, Limited, Warrington, has been appointed a director of Richmonds Gas Stove Company, Limited.

MR. C. G. LANGFORD, director of Richmonds Gas Stove Company, Limited, has been elected a director of Fletcher Russell & Company, Limited, of Warrington.

MR. A. H. C. PAGE, chief works metallurgist of the London Midland & Scottish Railway, has been awarded the Frederick Harvey Trevithick prize of the Institution of Locomotive Engineers for his Paper on the "Heat-Treatment of Metals in Connection with Locomotive and Carriage and Wagon Construction."

MR. WALTER S. TOWER has been appointed President of the American Iron and Steel Institute. This is now a salaried position. Mr. Tower was commercial attaché at the U.S. Embassy in London after the last war. He returned to the United States in 1924 to take up an appointment with the Bethlehem Steel Company.

MR. G. H. NISBETT, acting on medical advice, has relinquished his duties as managing director of British Insulated Cables, Limited, but will continue to act as deputy-chairman. His retirement from the former office brings to a close 46 years' service as an executive officer of the company, during the last 12 years of which he has held the position of managing director. As deputy-chairman, he will continue to be in close touch with the affairs of the company, but will be permitted a greater leisure than his duties have hitherto allowed. Mr. T. H. Martin-Harvey and Mr. W. Travis have been appointed joint managing directors.

Wills

CROMPTON, COL. R. E. B., director of Crompton Parkinson, Limited ...	£15,329
ROWELL, P. F., late secretary of the Institution of Electrical Engineers ...	£26,404
CRAVEN, E., of Sheffield, former chairman of Craven's Railway Carriage & Wagon Company, Limited ...	£31,471
GIBSON, N. W., of Kingston-on-Thames, formerly a director of H. J. Skelton & Company, Limited, iron and steel merchants	£1,531

Obituary

WE REGRET to record the death of Dr. E. F. Northrup, at the age of 74. He was vice-president of the Ajax Electrothermic Corporation, of Trenton, N.J., and was a pioneer in the development of the high-frequency induction melting furnace.

THE DEATH has occurred in Milngavie of Mr. James Tennant, a director of Alex. Findlay & Company, Limited, Parkneuk Works, Motherwell. He began his business career with David Colville & Sons, and over 40 years ago joined the former concern where, after the death of Dr. Gillies, he became chairman and managing director. Mr. Tennant, who was 80 years of age, retired about six years ago.

Reports and Dividends

J. Brockhouse & Company, Limited—Interim dividend of 7½ per cent.

Newton Bros. (Derby), Limited—Dividend of 12½ per cent. for the year to March 31.

Keith Blackman, Limited—Net profit for the year ended March 31, £32,770; ordinary dividend of 15 per cent.

Whessoe Foundry & Engineering Company, Limited—Dividend of 40 per cent. for the year ended March 31.

Glacier Metal Company, Limited—Dividend of 7½ per cent. on the ordinary shares for the year ended February 29 last.

Allied Ironfounders, Limited—Net profit for year to March 31, £112,424; final ordinary dividend of 2½ per cent., making 5 per cent. for the year.

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Raw Material Markets

Should we be unable to count further on France's active participation in the war and thus have no expeditionary force to maintain across the Channel, it will not in any way mean that the output of munitions within the British Empire can be relaxed. The immediate future of our noble Ally may be uncertain, but the determination of Britain to carry on the struggle is unquestionable. If the United Kingdom is to be turned into a fortress to combat the Nazi drive, the kind of munitions required may, to some extent, be different, but the entire resources of the iron and steel industry will continue to play a major part in the war effort.

Pig-Iron

MIDDLESBROUGH—Foundries in this area are now rather better placed; this, of course, applies to makers of light castings, heavy engineering establishments having been fully occupied on Government work for months past. The former trade is playing a large part in the contracts placed by various departments of the Government and, consequently, more iron is being called for from the Midlands, as production of Cleveland foundry iron is still suspended. Ironmakers meeting the needs of the steelworks remain very active, basic iron, especially, moving away freely. There has been a noticeable strengthening in the call for hematite, which has necessitated a closer watch on distribution to works not producing material vitally important to the war effort.

LANCASHIRE—So intense is the demand for iron from consumers engaged on war work that it may become necessary to stop altogether deliveries to other users. Distribution has already been tightened up and it is appreciated that the requirements of non-essential consumers must be put aside if they should in any way hinder the production of vital goods. Heavy electrical and machine-tool concerns are very active, while general engineering works and jobbing foundries are mostly very busy. Good deliveries of North-West hematite are being taken up in this district.

MIDLANDS—Light-castings makers not employed on Government contracts are finding it increasingly difficult to obtain high-phosphorus iron for the production of domestic castings, owing to the comparatively small output of this type of iron, many of the furnaces now being employed on the manufacture of other descriptions. The Government, being anxious to enlarge the export trade of the country, may assist the light-castings industry in fostering shipments of their products, but, otherwise, makers will have little work on their books. Heavy engineers are taking high-phosphorus iron, but their consumption of this grade is relatively small compared with the large quantities of low-phosphorus iron and hematite which they consume. Makers of these irons are able to meet orders satisfactorily, although there is none to spare.

SCOTLAND—A partial changeover to Government work has aided many light-castings makers in the Falkirk district, but idle time still persists at many works. Deliveries of iron from the English Midlands are coming to hand quite regularly. Heavy engineering concerns are consuming very large tonnages of pig-iron.

Coke

The distribution of foundry coke is keeping most consumers in a position to augment their stocks, despite the substantial rate of consumption. Ovens are transacting business on a forward basis, users paying the price ruling at the time of delivery. For delivery to Birmingham and Black Country stations at the present time, the price of Durham best foundry coke is 55s. 6d. per ton.

Steel

An announcement by the Iron and Steel Control last week stated that firms who had placed orders for finished steel, but had not supplied the necessary symbol, reference, and particulars required under the steel distribution scheme, which came into force in April, ran the risk of having those orders cancelled after Saturday, June 15. The Government is making every endeavour to ensure that steel supplies are reserved for works producing material for the Ministry of Supply and other departments and it is understood that inspectors are being appointed with a view to preventing discrepancies in the distribution scheme. The full outputs of the steelworks are passing immediately into consumption. In addition to the heavy needs of Government departments, there are other pressing requirements and makers are doing all in their power to satisfy these consumers.

Scrap

Good tonnages of scrap continue to be made available through the many collection campaigns in operation in all parts of the country. An example of the spirit of enthusiasm with which the public is co-operating with the authorities is contained in a statement issued on Monday, which announced that farm labourers and boys and girls in English villages had in 14 days established 962 village dumps for scrap iron and collected 750 tons of metal. Despite the increasing amount of home-produced scrap which is being placed at consumers' disposal, the demand still outstrips the supply and the necessity for importing material has by no means vanished.

Metals

Tin prices on the London Metal Exchange soared to above the £290 level at the end of last week, but Monday witnessed a fall of nearly £5 in the cash quotation, and on the following day the price declined by no less than £21 10s., the biggest reaction for many months past. This was brought about by a falling away of American buying owing to the political developments due to the French situation. Keen activity has recently prevailed in the United States, where buyers have been taking up all the metal that was available to them. President Roosevelt's reply to M. Reynaud's dramatic plea to the American Government for help indicated that U.S. industrial activity will be brought up to full capacity levels with the minimum of delay and tin promises to play an important *rôle* in the American bid to assist the cause of freedom, but at the moment buyers are marking time pending clarification of the position. In addition, the American defence programme will continue to forge ahead.

London Metal Exchange tin prices this week have been as follow:—

Cash—Thursday, £288 15s. to £289 5s.; Friday, £290 5s. to £290 10s.; Monday, £285 10s. to £285 15s.; Tuesday, £264 to £264 10s.; Wednesday, £266 10s. to £266 15s.

Three Months—Thursday, £289 15s. to £290; Friday, £291 10s. to £292; Monday, £286 10s. to £287; Tuesday, £265 10s. to £265 15s.; Wednesday, £268 10s. to £268 15s.

The demand for copper in the United States of late has been extremely active and, in the light of recent European events, consumption may be expected to attain very high levels in the near future. In recent months United States copper exports have helped to build up Italian reserves (although the latter are not thought to amount to any appreciable amount), but shipments have, of course, ceased and the copper which would otherwise have been sent to Italy will now be employed in the American industrial expansion, to the benefit of the Allies.

The demand for zinc in the United Kingdom continues to be on a very substantial scale, particularly for the higher grade brands. Galvanisers are not getting all the steel they require and, thus, the demand for f.o.b. metal is rather less than it would be if this trade were able to produce to capacity. Lead supplies destined for Britain may, to some extent, be adversely affected by the Italian intervention, but there need be no cause for alarm in this respect. Consumption in connection with the production of munitions is steadily expanding and there may be still less metal available in the future for the ordinary domestic user.

Design Desiderata in Gas Burners

Investigations by H. SCHWIEDESSEN, reported in a Paper in the "Archiv für das Eisenhüttenwesen," on the conditions of combustion of gas and air mixtures, indicate that the principal function of gas burners designed for mixing and combustion is to achieve the mixture of the gas and air in a specified space in such a way that complete combustion ensues. The factors, which determine the efficiency of the mixing action in these burners include the velocity of issue of the gas and air streams, the angle at which these streams impinge on each other, and the cross-sectional area of the two streams. The various types of burners on the German market can be divided into four well-defined groups, *viz.*, axial tangential-stream burners, parallel-stream or streamline burners, eddy-current or swirling burners, and air-suction burners. In practice, burners with mixing chambers should be avoided if further, usually inadequate, mixing is required in the furnace space to promote complete combustion. Efficiency depends, *inter alia*, on maintaining a uniform density of flow over the whole section of the burner and on keeping the pressure drop as low as possible. Simplification in the design of burners, while very desirable, can, in the author's view, only be achieved by an exhaustive analysis of the conditions of flow in the burner and a correlation of a vast number of independent measurements. Current designs show an increasing complexity, and the author suggests that this elaboration should be countered by more and more attention being given to simplicity. Standardisation is also a desirable aim, since this will remove many of the shortcomings now inherent in burner design and due to their complexity.

Publication Received

Surface Treatment of Aluminium Castings, in the May issue of "Aluminium Technique." Published by Aluminium Union, Limited, of The Adelphi, Strand, London, W.C.2.

This comprehensive article covers the preliminary operations, roughing; "greasing" (a polishing process); buffing, hammering and barrelling; sand-blasting (not shotblasting, as the latter process is too drastic); chemical treatments; anodising; chromium plating; and painting. The article is full of data and useful hints and should further information be required, it can be obtained on application to the issuing company.

F. B. McKune Memorial Award

The Open-Hearth Steel Committee of the American Institute of Mining and Metallurgical Engineers, 29, West 39th Street, New York City, will present the F. B. McKune Memorial Award for the best Paper of not more than 5,000 words on open-hearth practice offered for presentation at the 1941 conference of the Committee. The award will be made to a man not more than 35 years of age. This award was authorised by the Open-Hearth Conference at its meeting last April in Pittsburgh as a memorial to the late Frank M. McKune, who, from 1899 to 1939, was superintendent of the open-hearth department of the Steel Company of Canada, Limited. The award will consist of $100 and a suitable certificate, and the recipient will be the guest of the Open-Hearth Steel Committee while at the 1941 Open-Hearth Conference. Papers submitted for consideration for this award must be in the hands of the Award Committee prior to January 1, 1941. Five copies of each Paper must be submitted. The prize Paper becomes the property of the Open-Hearth Steel Committee. The Papers submitted will be considered by a board of judges comprised of representatives of steelmaking, refractories, combustion, and practical open-hearth operating interests.